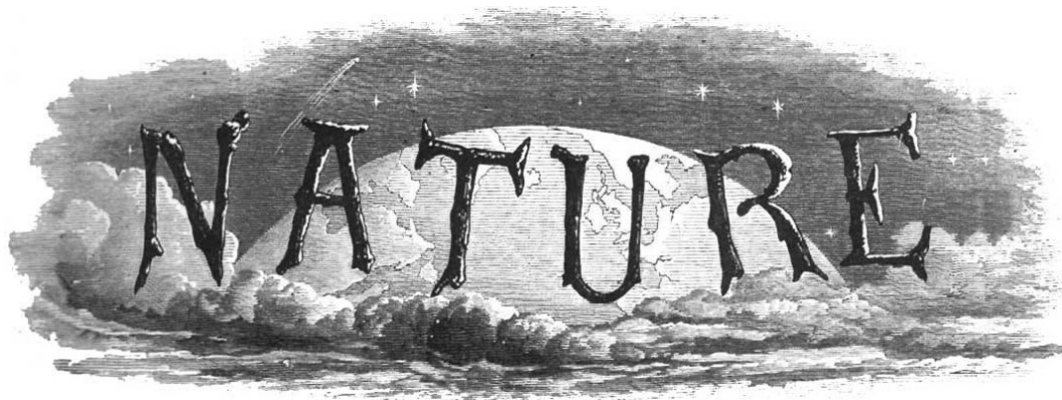




A WEEKLY ILLUSTRATED JOURNAL OF SCIENCE.

*"To the solid ground
Of Nature trusts the mind which builds for aye."*—WORDSWORTH.

THURSDAY, MAY 5, 1904.

THE METALLURGY OF STEEL.

The Metallurgy of Steel. By F. W. Harbord, A.R.S.M., F.I.C. With a Section on the Mechanical Treatment of Steel by J. W. Hall, A.M.Inst.C.E. Pp. xxiv+758. (London: Charles Griffin and Co., Ltd.) Price 25s. net.

A PONDEROUS volume, profusely illustrated, abounding in detail, probably the best yet published on the whole subject, yet a little disappointing, for, though necessarily to a large extent a compilation, it lacks more than need be that personal touch of the author in selection and presentation which the student so much appreciates. Such is the feeling left by a careful reading of the work. The subject is taken in four parts:—(1) the manufacture of steel; (2) reheating; (3) the mechanical treatment of steel; (4) finished steel. It inspires confidence that the author as a metallurgist has induced the well known metallurgical engineer, Mr. J. W. Hall, to write part iii., and to join with him in the chapter on reheating.

The Bessemer processes, acid and basic, and all their modifications are very well described, and illustrations of various historically interesting as well as typical modern forms of converter are given, in many cases as working drawings with dimensions. The small converters for surface blowing have a special chapter to themselves, and the best known forms are described. It is well that it is so, for they bid fair to revive a little the fading glories of the Bessemer process by their suitability for the making of steel for castings.

The general scheme adopted is to describe the apparatus, then the process, next the reactions of the process, and lastly the thermochemistry, a method which involves some repetition but makes reference easy. The open hearth is similarly treated, such special furnaces as the Siemens new form, the Campbell, and the Wellman tilting furnaces being illustrated in great detail by means of folding plates.

The somewhat sensational Talbot process is carefully considered with the author's special facilities for exact knowledge in this matter. The chapter on steel castings is disappointing, and will serve to illustrate the feeling mentioned above. Few will admit that the beneficial effect of silicon and manganese on castings is due to their removing oxidising gases, or that aluminium in the quantities used increases the fluidity or removes the dissolved oxide of iron. The statement that annealing hard castings counteracts their tendency to fly when cooling is obscure, while the full table of Prof. Arnold's recent results on castings is given without any warning that these results are the basis of a research series, and that the steels are not suitable for commercial work, a point most clearly stated in the original. The weight of Prof. Arnold's authority on practical matters, combined with the relative space taken up by the table, will certainly tend to mislead the student here. The chapter finishes with three tables of three, two and two tests respectively, showing the effect of annealing, &c., yet from a remark in the text, the last two appear to be forgings.

The chapter on crucible steel is difficult to estimate, as to anyone acquainted with the innermost workings of the old crucible steel trade, with its meagre literature, it is almost impossible to judge as to how much a writer might reasonably be expected to know. To the general reader it will be sufficiently interesting, while the beginner in a works could point out many flaws. On entering the gate on a morning the author would find that blister bar is not "cut up," but broken with a hand hammer, giving out quite a musical series of notes as the bars become shorter. The crucible shown would be difficult of manipulation by "the teemer," the real "Sheffield pot" having a well designed and quite artistic shape. The sulphur does increase in melting, and a careful watch must be kept on the quality of the coke, or the rise will be serious, even in high carbon steels, where the carbon, according to the author, expels the sulphur, which somehow in practice it fails to do. The increase of phosphorus, if any, is not detected in ordinary working.

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In part iii., on the mechanical treatment of steel, by Mr. J. W. Hall, the excursions into theoretical matters of pure metallurgy are not always happy, but the other parts are treated as one would expect from an engineer of his enthusiasm and experience. The development of various types of mills, examples of modern plant, forging by the hammer and by the press, all seem excellently treated, while the case for and against fluid compression is made very clear. Several Sheffield firms, however, make high speed steels, generally acknowledged to be much more than "nearly equal to those at Bethlehem."

Part iv., by Mr. Harbord, on finished steel, treats of the metal steel itself, its mechanical properties, the relations of iron and carbon, influence of other elements, effect of heat treatment, and the microscopical examination of steel. Mechanical testing makes a good chapter, but why use the erroneous term "tensile strain" instead of "maximum stress"?

To the chapter on iron and carbon many will eagerly turn, because of the paramount importance of the subject in everyday work, its great historical interest, and it may be also because of recent controversy. Perhaps, therefore, one expects too much, but it must be confessed that the author does not seem to have risen to the occasion, and gives only a not too excellent compilation where one expected a sorting out and a grappling with the question. The well known diamond and iron *in vacuo* experiment is taken as proof that carbon can be transferred to iron without the intervention of gas, whereas it is now well known that steel which has ceased to give off gas even at 1000° C. will give off more if heated to 1200° C. After a description of temper (or annealing) carbon, "the existence of this form of carbon has not been confirmed by other investigators" is a rather startling statement. The research on "The Influence of Carbon on Iron," published by Prof. Arnold in 1895, and acknowledged by all to be a classic, is quoted, and with it some recent work of the author's own which only seems to obscure the subject. The author hardly deals fairly with his readers in withholding the tests of his steels as received, and the first three are given here (see sixth report Alloys Research Committee) side by side with ordinary commercial samples taken at random. It will be clear that they are a very undesirable series as a basis for such a research. The three numbers represent maximum stress in tons per square inch, elongation per cent. on two inches, and reduction of area per cent. respectively:—

Harbord ...	30	20	35	Harbord ...	33	13	25
Commercial	30	30	60	Commercial	35	28	47
Harbord ...	31	13	30	Harbord ...	37	6.3	19

The author seems almost alone at the present date in the opinion that "hardening carbon is possibly merely free carbon dissolved in iron," as even Stansfield, Osmond and Stead all favour the idea of carbide dissolved in iron, and the author ought to have told his readers this. He also says that the carbon theory does not explain the critical points in pure iron and

loss of magnetism, but surely he must know that the main function of the carbon theory is to explain the hardening of steel. He is hardly up to date on some important matters, as he takes Arnold's mere suggestion of long ago as to Ar_3 , and leaves the student to think that this is the present well defined position, whereas both sides are agreed as to Ar_1 being the real carbon change point, and to carbonists it represents the formation or decomposition of a substance corresponding to the formula $Fe_{24}C$. All are agreed also that the purest iron shows Ar_3 and Ar_2 , and Prof. Arnold's theory with regard to Ar_2 is quite sufficient to account for the disappearance of magnetism. The author should remember that the serious question is this, "Does a flint hard allotropic iron exist?" The allotropicists are more happy than the carbonists in that they have a crisp explanation for Ar_3 , if the use of another Greek letter as a prefix can be said to give satisfaction to any practical worker in the field. The solution theory is given in detail, but the author wisely dismisses the application of the phase rule to the problems of steel by reference to original papers, and the student who endeavours to follow these is in need of sympathy if he be well acquainted with the known facts.

The extremely difficult subject of the influence of various elements on steels is well considered, but the author implies that Le Chatelier was the pioneer in our knowledge of sulphide in steel, while everyone should know that that honour belongs to Prof. Arnold. Heat treatment of steel is discussed in twenty-seven pages, and the last chapter deals with the microscopical examination of steel, and several methods of preparation and etching are well described, but Fig. 448 should either be altered to suit opaque objects or removed.

The volume closes with 100 photomicrographs, four useful appendices, and a good index. The structures shown in several of the photomicrographs are not in accord with the writer's experience, but that might be due to abnormal crystallisation in the original steels, which seem to be identical with those used for the sixth report already mentioned. Several errors have been noted, but there is only room to indicate a few as examples:—p. 53, "wild metal which pipes in the moulds"; p. 101, incorrect definition of a heat unit; p. 227, the hardening power of liquids is said to be a function of their specific heats, whereas their conductivities are more important, as witness mercury compared with water; "microphotograph" all through the work instead of photomicrograph. On p. 680 0.8 carbon steel is indicated as saturated, while on p. 681 it is 0.9, and the footnote to p. 684, "The latest research has shown that it should be 0.9," gives a wrong impression. It had no need to be shown after 1895, as Arnold made it quite clear then, and others, perhaps working on impure steels, claimed 0.8, but now they have seen their error and 0.9 is accepted almost universally. On the whole, however, the book is to be recommended as the best available on the metallurgy of steel.

A. McWILLIAM.